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ABSTRACT

Current approaches in developing and applying computer assisted instruction in language arts are described in this paper, which presents diverse positions along a continuum of perspectives and draws contrasts between a reductionist or subskill approach and a whole language emphasis. The paper discusses three predominant computer applications in teaching composition: teaching writing through knowledge of grammar; leading students through the writing process, using computed-based tutorials; and combining the talents of teachers with word processing programs. The paper then explores the capability of the computer to teach reading--using both subskills and a whole language approach. Finally, issues important to the future use and development of this technology are discussed, and recommendations for new language arts software are presented. (DF)

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Computers and the Language Arts

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CS 209 172

Computers and The Language Arts

Introduction

James touches the screen with a light pen as words float across the screen. The target word for the lesson as well as distractors move in an apparent random pattern.

"Jump," says a voice reminiscent of HAL, the computer in the movie 2001. Each time the pen touches the correct floating word, the voice repeats the pronunciation. For 15 minutes each day, James is introduced to new words on the computer. Words are presented and pronounced several times. After the initial teaching sequence, the chase activity provides practice. The computer records the number of correct answers, requiring James to achieve 90 per cent accuracy before introducing a new word.

This scene describes one use of computers in the language arts area. Consider a second situation.

Rebecca, paired with her friend Liza, finishes the second page of "An Unusual Friend", a computer-based reading strategy lesson focussing on predicting and confirming. Calling up the answer screen, she reads the five predictions they decided upon after reading the first page of text.

1. dog
2. monkey
3. Karla's cousin
4. cat
5. skunk
6.

"Well, the unusual friend can't be Karla's cousin, " Liza laughed. "I don't think he could fit under a baseball glove." She pressed the delete key and Karla's cousin disappeared from the screen.

"What about monkey? " Rebecca asked. "I don't think that's a good prediction either."

"Why don't we keep it for one more page? Maybe it's a small monkey," Liza responded.

During the next 15 minutes, Rebecca and Liza read each page of the story, deleting and adding predictions according to their background knowledge as well as the cues contained in the text. At the conclusion of the exercise they wrote down three plausible final predictions to bring to a small group discussion on the story.

These scenes represent two extremes in applying computer aided learning (CAL) to the language arts. The diversity is not a technology related issue as the programs described are available now. Indeed, technology is seldom an inhibiting factor in developing CAL programs for the language arts. Instead, the key issue focusses on how one describes language processes and, more important, how one views children's acquisition of language processes.

Overview

The purpose of this paper is to describe currrent approaches in developing and applying CAL to the language arts. For the purpose of illustration, diverse positions, along a continuum of perspectives, will be presented. Specifically, contrasts will be drawn between a reductionist or subskill approach and a whole language emphasis. Representative CAL applications in both reading and writing will be discussed. The focus on writing and reading separately is for convenience, probably mine; in the real world of schools, such a separation, especially from a whole language perspective, would be untenable.

The emphasis on learning issues rather than technology is important to this paper. Few early CAL programs in the language arts were based on a stated theoretical orientation. Instead, developers were guided by the capabilities of computers. Although some recent language arts software is based on explicitly stated learning principles, technological virtues continue to be touted.

Following the discussion of current computer-based applications to the language arts, I will focus on issues important to the future use and development of this technology. An important recommendation is that software creators must become attuned to our current understanding of how language processes are acquired. As well, I contend more attention needs to be given to the interaction among computer, teacher and learner.

Writing

There are three predominant computer applications in teaching composition. Underlying each is a stated or implied view of the writing process and how children develop as writers. Teaching writing through grammar knowledge is one popular CAL approach. Another is to lead the student through various steps in the writing process using computer-based tutorials. The final school of thought advocates combining the talents of teachers with word processing programs.

Grammar and CAL

Two types of CAL programs to develop composition ability through grammar dominate the educational market. The first, using a tutorial format, presents the student with examples of a grammatical rule or syntactic pattern. After reading definitions of rules or examples of grammatical principles, the student completes a series of exercises designed to test mastery. Examples of such programs are English, Volume 1 (MECC) and Lessons in Syntax (Dormac). The second format dispenses with the examples and offers practice only. Often these types of programs use an arcade format where the student must demonstrate grammatical knowledge under timed conditions.

In promoting grammar programs, publishers stress features such as specific skills development, graphics, instant feedback, and automatic record keeping. Advertisements frequently use educational catchwords such as "mastery learning" and "basic skills". Some of these so-called virtues relate directly to the capabilities of computers(e.g., graphics and automatic record keeping), while others, based apparently on technology, focus in reality on learning theory(e.g., instant feedback and specific skills). Behaviourism, whether stated or implied, is the guiding theory for these programs. Congruent with these behaviouristic underpinnings, is the notion of reductionism.

Although teachers tend to call for creative uses of computer software in the language arts, a recent survey in Ontario shows that drill and practice programs such as those focussing on grammar continue to be used frequently (Canale, McLean and Ragsdale, 1983). The contradictions brought out in this report perhaps indicate a gap between research and practice. Research has shown consistently that teaching grammar in isolation does not enhance general composition ability (Weaver, 1979). As well, the value of a behaviouristic perspective in teaching humans generally, and language specifically, is highly suspect (Chomsky, 1959). Thus, we have a paradoxical situation where teachers continue to use programs based on a bankrupt theory of learning, and where information is presented often in the absence of any supporting linguistic context. The use of these types of programs contradicts the accummulated results of research as well as at least one provincial guideline in the language arts (Ontario Ministry of Education English Guidelines, 1977).

Writing Assistance through CAL

Recent CAL programs attempt to wed technology with the notion of a writing process approach in fostering children's composition ability. Often using the idea of a five step writing process approach-prewriting, writing, revision, editing, and publication-software developers created programs to assist students with one or more of these areas. Some programs were designed to help specifically with a troublesome area, for example, choosing a topic (Tchudi, 1983) or editing (Macdonald, Frase, Gingrich, and Keenan, 1982). More ambitious programs such as Quill (Rubin and Bruce, 1984) attempt to develop all aspects of the writing process.

Unlike CAL programs in grammar, where students manipulate the language of others, writing assistance programs are designed so students actually write. However, this is not to say all follow the same tenets. For example, Cronell (1982) advocates the use of interactive videodiscs to present animated or live-action stories as a stimulus for composition. A help menu would permit review of a video, provide possible direction in composing and offer words that might occur in the story. In contrast, a CAL program developed at the Ontario Institute for Studies in Education by Woodruff, Bereiter and Scardamalia (1981) is designed so students involved in essay writing can call up prompts from a help menu whenever they become stuck.

To offer the reader a clearer picture of how writing assistance CAL works, I will describe a recent program entitled "Creating a Character Sketch" (Minnesota Educational Computing Consortium, 1983) which uses a tutorial approach. Students choose to write about a fictional character, historical figure or personal acquaintance. Once a name is selected, students are asked to type in two words describing this person. At this point they begin a journey through a series of topics and subtopics related to writing a good character sketch. For example, the student may select BEHAVIOR as the first major topic. Once a major topic is selected, subtopics, such as HOW THE CHARACTER ACTS OR WHAT THE CHARACTER SAYS, may be explored. At each juncture the student may see examples of the characteristic, take a short test to determine understanding, or enter up to six lines of a description. This procedure is repeated for a variety of topics including external characteristics, behavior, other's reaction and comparison/contrast. A printout of the student's descriptions provides the outline for a complete character sketch.

Perhaps the most elaborate CAL writing program is Quill, developed by Andee Rubin and her associates at Bolt, Beranek and Newman (Rubin and Bruce, 1984). Quill comes closest to providing assistance in all five of the writing process steps. To accommodate the prewriting step, Quill contains a program called Planner, which encourages organized note taking. Writing is handled by a word processor while a text editor facilitates both higher level revisions and editing. Publishing is aided by a utility program called Publisher. Publisher allows for easy formatting of newpapers and books, two ways of making writing public. A final feature is Story Maker, a program developed previously by Rubin (1980) and incorporated into Quill. Story maker has several uses, but I believe fostering idea development and higher-level story organization are the most important.

It is more difficult to describe the theoretical bases of writing assistance programs than those meant to develop grammatical knowledge. CAL programs in grammar may differ in technological effects, but their theoretical principles are similar. Writing assistance programs differ substantially from each other although two common elements among them are evident. First, most view writing as a cognitive act, which contrasts with the behaviourist approach of grammar programs. Some programs, such as Quill, go beyond an implied cognitive orientation; they explicitly base their components on the work of such researchers as Graves (1981; 1983), Flower (1981), and Emig (1977), to mention a few. A second consistency in writing assistance programs is the goal of having students engage in real writing. Often students are given help in choosing topics; other programs aid in revising stories. In all cases students are producing connected discourse, often for a self-selected purpose, and not simply manipulating text or isolated words written by someone else.

I believe writing assistance CAL goes far beyond the values of grammar programs. However, shortcomings in these former programs exist also. The models of excellence presented in these programs may be just that, but they represent (usually) only one example of good writing. There may be a tendency for students to assume this is "the" way to produce a piece of good writing, following the model in a slavish manner. As mentioned previously, few writing programs allow the student to go through all five steps in the writing process. Some could be exempted from this criticism as they may be based on a different view of how the writing process develops. But this exemption leads to another potential criticism--the absence of an explicitly stated theoretical base for the program. Like most grammar oriented CAL, writing assistance programs often lack an adequate description of their theoretical principles. Therefore, the user is left to infer how the authors view writing development.

Some writing assistance programs, in their prewriting or revision segments, use a technique similar to the famous ELIZA program developed by Weizenbaum in the 1960s. This program mimicked a technique of nondirective psychotherapists by taking words and sentences of the user and converting them into questions. Like ELIZA, writing assistance programs are limited by their data base, that is, they can respond only to items already stored in memory. Therefore, students may be straightjacketed into asking questions suited to the computer's capabilities rather than their concerns.

Another problem with writing assistance CAL lies in editing programs. Editing programs typically compare the structural aspects of a piece of writing with stored data. This means the rules of writing are preordained, which may cause difficulty. For instance, a student attempting to capture the flavour of Newfoundland dialect might discover a sealer sounding like an Oxford graduate. An cliche of the writing profession is that good writers know all the rules of writing--and break them regularly. The purpose of editing programs is correction, not instruction. Depending on how editors are used, they may confuse or enlighten students.

Writing assistance programs appear to be founded on a whole language perspective. And in many instances this is true. Some programs, however, break the steps of writing into minute segments, presenting them in a lockstep manner. In spite of claims to the contrary, close examination reveals these programs to be based on reductionist notions of learning.

Word Processors and the Composing Process

Few technological advancements have captured the immagination of writing teachers as the word processor. Initial interest was heightened as special word processing programs for children, such as the Bank Street Writer (Scholastic), were introduced. On first examination, it seems to be a perfect tool for fostering composition development, carrying the potential to eliminate many traditional roadblocks in effective instruction.

Word processing programs, unlike either grammar or writing assistance CAL, combine technology with the talents of teachers in fostering the writing craft. Authors such as Graves (1983) advocate a master/apprentice relationship between teacher and pupil where the student is led through multiple drafts to a polished piece of writing. The computer eliminates the drudgery of handcopying drafts so students are free to concentrate more on revision and editing. As well, since the computer does not take over all instruction, teachers can work on those areas where human interaction best serves the needs of the students.

The values of word processors appear to go beyond the obvious benefit of eliminating recopying. Teachers report children using word processors have a propensity to generate longer stories. The reasons for this include novelty, the prodding effect of the cursor, elimination of the messy page which prompts some children to begin again, the congruency between typing speed and thinking, and teachers' willingness to allow children free selection of topics (Miller, 1984). Another distinction is the ease of revision and editing afforded by the word processor's help menus. Children show the capacity to revise as early as grade one, and the word processor may enhance this ability (Graves, 1979; Sowers, 1979).

As mentioned previously, word processors do not possess the tutoring capabilities of other types of CAL programs. Word processors carry no explicit or implicit theory of how the writing process should be fostered. Children could be required to use word processors to create long lists of words, say derivatives of root words, instead of original stories. Rather than using multiple drafts in writing conferences to develop children's revision abilities, teachers simply may hand back hemorrhaging papers for recopying.

Word processors cannot be praised or criticized in the same manner as grammar or writing assistance CAL programs. Instead, observers must look at how teachers apply their theories as to how composition can best be nurtured using word processors. And these observations must be based not on teacher's espoused theories but on their theories in action. The word processor would appear to facilitate a whole language approach to writing; whether or not it will be used in this manner is uncertain.

Summary

Three applications of technology to the development of children's composing abilities have been described in this section. Each application tends to view children, and how they acquire the writing craft, in a different manner. However, this is not to say there are not some overlapping notions. Schwartz (1984), for example, combines the values of writing assistance programs with word processors, selecting aspects of the former mode to supplement the use of the computer as tool. I believe Schwartz is on the right course here. She implies that knowledgeable teachers, aware of how language processes are acquired, will select appropriate teaching aids and tools to foster learning. The technology tail is not permitted to wag the writing process dog.

Reading

The subskill versus whole language controversy is more pronounced in the area of the reading than writing, at least in the literature. In writing, one seldom reads a current article arguing for the teaching of writing as a set of discrete components or subskills. However, in reading, subskill approaches to instruction, following the notions of LaBerge and Samuels (1974) and other bottom-up theorists, are common (e.g, Otto & Askov, 1974). Furthermore, researchers are applying theory directly to computer applications. Leigold (1983) comments:

> I see a primary role for microcomputers in providing pleasant opportunities for children to practice recognizing words and component parts of words, to practice making decisions about the meanings of words quickly, and even to practice higher-level reading activities-but always with the emphasis on practice to improve efficiency, not on initial learning. (p. 174)

Collins and Smith (1982), arguing from a different theoretical perspective, see instruction in comprehension monitoring and active hypothesis testing as attractive applications of computer technology.

In this section, I will discuss current applications of computer technology to reading using the dichotomy of subskills and whole language. As with the discussion of CAL and writing, the dichotomy is for my benefit as a writer since the real world tends to blur at least some of the distinctions I will describe.

CAL and Reading from a Subskill Perspective

Subskillists break the reading process into component parts. Some, such as Gough (1972), describe this process in a linear, hierarchically ordered manner. Although not based on Gough's description of the reading process, instructional packages such as Distar (SRA) tend to subscribe to this general idea. To the best of my knowledge, there are no existing software programs in reading, on the scale of the Distar package, that adhere to a linear, hierarchically ordered instructional sequence. However, there are numerous CAL programs presenting aspects of reading as isolated skills. Some of these will be discussed here under common subskill headings such as word identification, vocabulary and comprehension.

Word Identification: Probably the first computer applications to the language arts were in the area of word identification. Beginning with the pioneering Stanford CAI project in beginning reading (Fletcher and Atkinson, 1971) and continuing to current public domain programs for home microcomputers presenting words in a flashcard manner, the emphasis on word identification dominates the way in which computers have been used to teach reading. A recent survey of 317 language arts programs by Rubin and Bruce (1984) showed most dealt with language at the letter or word level. Depending on one's theoretical outlook, this finding may be interpreted positively or negatively.

There is a wide range of word identification programs, falling into several categories (Mason, Blanchard and Daniel, 1983; Geoffrion and Geoffrion, 1983). One category is sight word development. Whether the program is written in BASIC presenting words one after another, or uses Winchester discs to allow the matching of visual stimuli with auditory reinforcement, the thrust is to develop speed and accuracy in pronouncing words in isolation. These programs rely on oft-praised virtues of CAL--graphics, controlled speed of presentation, instant feedback, and automatic record keeping.

The second major category centres on developing phonic skills. Although large mainframe computers, and some powerful microcomputers, have voice synthesizers, most phonic skill CAL programs are designed for computers without this capacity. A typical exercise might use the following format:

1. Find the word that ends with the same sound as right.

   a. root b. night c. neigh d. stair

Other programs, using graphics, require students to match pictures with beginning, medial or ending sounds. For example, the student is shown a picture of a star with the command to find a word that begins with the same sound. Advocates of computer-based phonics cite instructional values similar to those given for sight word programs.

In addition to these main thrusts in word identification, there are numerous programs purporting to supplement instruction in this area. Word searches, hangman type games, and word building are typical supplemental programs. In one such program, students try to combine prefixes and suffixes with roots to form words. If a word is formed, by design or accident, the definition of the word is given.

Nearly all word identification CAL programs use a subskill approach to teaching, with words or word fragments presented in isolation. Furthermore, most are based on behaviouristic learning principles. Depending on one's viewpoint, this may interpreted as sound or unsound. I believe it is unsound. In addition to the theoretical perspective issue, there are several other flaws in these programs. First, most programs do not teach; they test. Next, often children must be good readers already to follow the instructions accompanying the exercise. In many instances, it could be argued that anyone who can read the directions to an exercise doesn't need it. Finally, students often can demonstrate mastery without actually using the skill being taught or tested. For example, children can perform some phonics exercises by simple visual matching, not relating phoneme to grapheme.

Vocabulary and Comprehension: Wheeler (1982; 1983) points out that CAL programs in reading often resemble basal workbooks. This observation is especially valid when examining programs designed to develop vocabulary and comprehension skills. As with word identification programs, little instruction is carried out. In vocabulary programs, children are given a word and four possible synonyms; comprehension CAL presents a paragraph, question and four possible answers. The computer presents text, turns pages, gives feedback in terms of correctness, and records performance. Even a cursory examination shows many of these programs to be nothing more than electronic tests.

A few vocabulary and comprehension programs move beyond the test format. Context is introduced in sentences to guide the student to the meaning of a word; then the student is tested. Comprehension programs may tell students to return to certain parts of a story or paragraph if they select the wrong answer. Introducing context or guidance moves programs away from a rigid "subskills in isolation" orientation. How far these features move them along the continuum is debatable. Perhaps the key variable is how teachers use these programs.

Whole Language Approaches: I see a whole language approach as having (at least) the following traits: (a) an emphasis on process not product, (b) language presented to the learner in context, and (c) the language arts-speaking, listening, reading and writing-woven together throughout the learning in a supportive manner. Given these minimum characteristics, few CAL programs in reading would qualify as espousing a whole language orientation. Indeed, almost by definition, any program dealing with only one aspect of the language arts, such as reading, would be exempted from having a whole language orientation. Most CAL programs in general, and the language arts in particular, are designed to be self-contained, that is, interaction among teacher, student and computer is eschewed.

Accepting the fact no one CAL program constitutes a complete whole language approach, some appear to fulfill the requirements in part. Quill, described earlier in the writing section of this paper, is a superior program, combining the language arts even though its emphasis may be on writing development. As part of the Quill program, students engage in note taking, discussion, reading, research and publication, to mention a few activities. Another interesting program is Missing Links (Sunburst Communications), recently described by one of the authors, Carol Chomsky (Chomsky, 1984). Missing Links, using connected discourse from literature and non-fiction sources, creates multiple forms of the progressive cloze technique to foster awareness of orthographic constraints, syntax and semantics. Students can "solve" passages stored in the computer or create original stories for other children's attempts. Suspect Sentences (Ginn) permits students to insert a fraudulent sentence in a literature passage. Other students are challenged to detect this sentence. Follow-up discussion, focussing on the basis for the detective's suspicions, brings out writing features such as style. These are a few of the current programs congruent or partially congrent with a whole language emphasis.

I have been part of a development team consisting of teachers from the Frontenac and Scarborough Boards of Education and researchers from Queen's University involved in creating a special purpose tool in reading using a whole language orientation (Burnett and Miller, 1984; Miller and Burnett, to appear). The Puzzler, based on the notions of Goodman and Burke (1980), is designed to foster the reading strategies of predicting and confirming. This tool breaks many rules of traditional CAL programs in that it avoids elaborate graphics, offers no feedback, does not keep performance records, and considers the involvement of teachers as important as the disc-based lessons. The Puzzler begins with a whole group introduction to the process of predicting/confirming using overhead transparencies. Once the principles are established, students "puzzle" through a series of computer-based exercises requiring them to apply the strategies. Finally, small group follow-up is used to share ideas about the congruency of student's predictions at a given part of the stories. A future step in the development of The Puzzler involves students in writing original strategy lessons for inclusion on a special story creation disc.

Some CAL tends to defy classification, but I view two recent programs as compatible with a whole language emphasis. The Georgia Language Experience Recorder (Mason and Phillips, 1983) permits teachers to enter children's original language experience stories. Moreover, it contains features that allow teachers to examine the word choices of students, do word counts, and develop lists for sight word teaching and testing. This tool may prove useful in research, such as that being carried by my colleague Robert Hill (Research in Process), who is examining the difference between sight word lists developed by reading specialists and words actually used by children in language experience stories.

The second promising program is Microzine (Scholastic), a computer based magazine for children ages ten and up. In general, Microzine contains stories, interviews, puzzles, activities and games, many of which are interactive. My particular interest in this program centers on Twistaplot, a feature similar to the popular "choose your own ending" stories available in book form. Here, students can read stories over and over, each time selecting different twists and turns in the plot. Repeated readings for a child-directed purpose are the result of this feature. Repeated readings may be seen as a vehicle to develop automaticity in word identification, and this value cannot be denied. However, I believe Twistaplot stories foster higher level understandings such as plot structure, the choices authors have in writing, prediction, and comprehension monitering.

Summary

Like the writing arr , the majority of available software in reading is based on reductionism. Word identification programs, where letters, words and parts of words are presented to students in isolation, predominate the market. CAL programs designed to develop vocabulary and comprehension skills tend to emulate exercises found in basal workbooks, and capitalize on the computer's ability to turn pages, provide instant feedback, record performance and control rate of presentation.

The few programs available based on a whole language perspective tend to involve children in active hypothesis testing, comprehension monitoring, and writing as well as reading. Moreover, many of these programs are part of larger instructional packages where the computer is just one agent in teaching. Although some programs of this type make use of traditional computer attributes(e.g, record keeping), others attempt to give the student control over the machine.

Computers and the Language Arts--Future Directions in Development and Research

Some researchers such as Lesgold contend drill and practice programs constitute the most productive use of microcomputers; I believe drill and practice programs fall short of tapping the potential of this technology. Wheeler (1984) uses a set of guidelines for evaluating special purpose tools in reading applicable to software in the language arts generally. Chomsky (1984) forwards some additional ideas for effective CAL programs. I have combined the thinking of Wheeler and Chomsky to create the following list of principles:

1. Language arts software should be based on a learning theory that is clearly stated in the documentation.

2. The program should help students develop effective strategies for understanding and producing language.

3. The program should encourage the expression of ideas, allowing time for reflection.

4. Reading selections should be taken from or indicative of quality children's literature.

5. The program should allow teachers and students to enter original work or to customize the existing material.

6. The program should be useable many times and remain interesting and worthwhile.

7. Software packages should combine the talents of teachers with the capabilities of computers.

This list does not exhaust development principles, but it departs from many of the existing tenets of software creation.

There are programs in use today congruent with many of these guidelines; others are in the development stage. Collins (1983) recently described several new thrusts in software development that hold promise for fostering the language arts. Information retrieval systems will facilitate research skills. The books called up from this system will be interactive, allowing students to browse electronically using key words. Automated dictionaries will provide definitions, pictures and examples of unknown words in the context of the text. If a topic is especially difficult, the student will be able to call up expanded, and perhaps easier, versions of the text. Student projects are facilitated by these types of systems, and writing programs such as Quill provide writing assistance and publication capability.

Message systems, such as the one set up by Levin (1982), will permit students in different provinces or countries to communicate by computer. This will facilitate purposeful writing and reading by permitting pen-pal networks and shared projects. As these networks expand, students will be able to tap into large information data bases.

As writing assistance programs become more sophisticated, they will provide students with meaningful help in composition. The key in this development will be tailoring the aid to the individual needs of students. Quill certainly is an indication of what is possible in this area. As well, teachers will continue to combine their teaching talent in fostering writing by using word processors.

Research Directions

Much of the research in CAL and the language arts has been directed toward producing software. What is the machine capable of? This seems to have been the guiding question in developing early CAL programs, although in many instances it remains the prime force. Research is now being carried out to answer another set of questions. These are:

a. Can the computer carry out an instructional function better than a teacher?

b. Can the program support the work of the teacher?

Instead of asking what the machine can do, many researchers are now asking, "What do we want the machine to do?".

This type of question leads to a second major shift in CAL research. Researchers now are looking past hardware and software to learning. The theoretical soundness of programs is becoming an issue. As well, the nature and quality of learning that takes place through CAL is being investigated. I know from field tests of The Puzzler that developer's priorities often look first at computers rather than learning questions. The most important question asked is "Can kids crash the program?". This may be of importance, but a better question to ask in the case of The Puzzler is "Do children show evidence of using predicting/confirming strategies outside the program?". In other words, is there a transfer effect to the real world of print? Just what are students learning from CAL? Other than a few "My program is better than the book studies.", this question remains to be tackled. A few researchers, led by the group at the Bank Street College (e.g, Pea and Kurland, 1983) are examining the cognitive effects of computer learning, but much work remains.

Even some of the apparent values of computers require investigation. Teachers report frequently that children write longer stories using word processors. But are longer stories necessarily a virtue? Are they simply adding to the teacher's marking load or are these stories being used to foster composition skills such as revision? We don't know. Teachers report also that reluctant readers as well as children with so-called short attention spans will spend hours working on a microcomputer. We don't seem to be asking if they are learning anything.

A final neglected area of research lies in the social context of learning. Only recently has this area attracted attention (Hawkins, 1983). How are teachers dealing with this new technology? Do they view it as saviour, as some would have us believe, or is it viewed more as a Trojan Horse (Olson, 1984)? The computer once was praised as an instrument of individualized instruction, but early studies show more productive learning may take place when children work in groups (Burnett and Higginson, Research in Progress). These important issues need study.

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